Arnold Schwarzenegger
Governor

DAIRY POWER PRODUCTION PROGRAM

DAIRY METHANE DIGESTER SYSTEM 90-DAY EVALUATION REPORT - EDEN-VALE DAIRY

PIER FINAL PROJECT REPORT

Prepared For:
California Energy Commission
Public Interest Energy Research Program

Prepared By:
Western United Resource Development, Inc.

WESTERN UNITED RESOURCE DEVELOPMENT, INC.

December 2006
CEC-500-2006-083

Prepared By:
Western United Resource Development, Inc.
Michael L. H. Marsh, *Chief Executive Officer*
Tiffany LaMendola, *Director of Economic Analysis*
Modesto, California
Contract No. 400-01-001
Dairy Power Production Program Project No. 249-B

Prepared For:
California Energy Commission
Public Interest Energy Research (PIER) Program

Zhiqin Zhang
Contract Manager

Elaine Sison-Lebrilla
Program Area Team Lead

Martha Krebs, Ph.D.
Deputy Director
ENERGY RESEARCH AND DEVELOPMENT DIVISION

B. B. Blevins
Executive Director

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I. Program Background

The purpose of the Dairy Power Production Program (DPPP) is to encourage the development of biologically based anaerobic digestion and gasification ("biogas") electricity generation projects on California dairies. Objectives of the program include developing commercially proven biogas electricity systems that can help California dairies offset the purchase of electricity and providing environmental benefits by potentially reducing air and ground water pollutants associated with storage and treatment of livestock wastes.

The California Energy Commission (Energy Commisison), acting under authority of the Legislative enactment in 2001 of SB5X (Section 5(b)(5)(C)(i)), appropriated and encumbered funding for the Dairy Power Production Program (DPPP). Western United Resource Development, Inc. (WURD) was selected by the Energy Commission as the Contractor for this program.

To date, a total of 14 projects have been approved for grants totaling $5,792,370. The projects have an estimated generating capacity of 3.5 megawatts.

Two types of assistance were made available for the grant program: buydown grants, which cover a percentage of the capital costs of the proposed biogas system, and incentive payment grants for generated electricity. Buydown grants cover up to 50% of the capital costs of the system based on estimated energy production, not to exceed $2,000 per installed kilowatt, whichever is less. Electricity generation incentive payments are based on 5.7 cents per kilowatt-hour of electricity generated by the dairy biogas system, which totals the same amount as a buydown grant paid out over five years.

The grant program is overseen by an advisory group comprised of representatives from the California dairy industry; California Department of Food and Agriculture; California Energy Commission; California State Water Resources Control Board; Sustainable Conservation; University of California; and U.S. Environmental Protection Agency AgSTAR Program.

II. Dairy Profile

The dairy owner applied for a buydown grant from the Dairy Power Production Program to design and install a new plug flow digester. The dairy is located in Kings County on 145 acres, of which 100 acres are used for growing corn and wheat.

For the 90-day study period, January through March 2006, there were an average of 1,400 cows on the dairy, of which 800 were lactating cows, 150 dry cows, and 450 heifers and calves. An additional 280 calves and heifers are housed off-site.

Eden-vale dairy

III. Costs/Funding

The dairy owner was awarded a buydown grant $300,000 to install a new plug flow digester system. It was estimated that the total project costs for the system would be $661,923, of which

the dairy owner was eligible for up to 50 percent, not to exceed $2,000 per installed kilowatt. However, though the dairy owner applied for a capacity of 180 kW, the advisory group approved the project for a capacity of 150 kW, making the dairy owner eligible for a maximum of $300,000, slightly less than 50% of the total estimated costs for the project.


Digester under construction

To date, 50% of the grant has been paid to the dairy owner. As of April 2006, the dairy owner had spent approximately $750,000 on project completion, or $88,077 above the projected cost of the project. However, not all project costs have been reported, and the dairy owner expects to incur additional costs as the project is fine tuned. Some of the additional expenses incurred can be attributed to inflation over time, as material and construction costs increased between project planning in late 2003, when initial costs were estimated, and the actual time of project completion in late 2005. Over the $750,000 reported, the dairy owner also allocated approximately $50,000 in personal and dairy labor as well as equipment use for digester-related construction activities.

The dairy owner operates the system himself. The dairy owner and staff spent much time maintaining the system and monitoring performance. Approximately 15 minutes a day are devoted to digester recordkeeping, and about 20 hours a month are spent on digester maintenance, including oil changes and spark plug replacement, along with other routine maintenance and system repairs. Approximately two hours a day are spent on manure collection, although manure collection was already being done before installation of the digester. Oil changes are scheduled every 200-500 hours or approximately 2-3 times a month (assuming the engine runs 24 hours/day). Operating costs for oil, oil sampling, spark plugs, air cleaner, valves, filters, and time spent monitoring the system amount to at least $1,500 per month. Operating costs associated with manure collection amount to approximately $2,100 per month; including labor, equipment usage and maintenance, and fuel. Again, manure collection was already a standard part of dairy operations prior to construction of the digester and is not considered to be a cost associated with the digester system.

IV. Timeline

The original application was submitted to Western United Resource Development, Inc., on September 2, 2003. After thorough screening and review of the application, the advisory group approved the project for funding in November 12, 2003. It was originally expected that the project would operate by December 1, 2004. However, due to some outside obstacles (as explained below), the system did not begin operating until January 1, 2006.

V. Outside Obstacles

Low milk prices have had a significant impact on participants in the program. Beginning in late 2001, low milk prices began to put a strain on a dairy farmer's ability to obtain funds to invest in methane digester projects. Prices received by dairy farmers were at the lowest levels witnessed in more then 25 years. Though dairy markets are typically cyclical in nature, producers

experienced more than 20 months of extremely low prices. These low prices were, in most months, below a dairy producer's cost of producing milk.

Another major roadblock to completion of this project was difficulty in obtaining a Rule 21 interconnection permit from Pacific Gas & Electric Company (PG&E) so that the project could generate power parallel with the main grid. The dairy owner reorted some specific delays, particularly in the testing process. A transformer located at the utility building was determined to be too small by PG&E, and a service upgrade was required. The dairy owner was quoted a 22-26 week lead time to change out the transformer. The work was actually completed ahead of schedule, in approximately 16 weeks. Some issues with the generator supplier also held up the interconnection process somewhat. There were also some reports of minor malfunctions in the switchgear that subsequently delayed PG&E's pre-parallel test needed to approve interconnection. Overall, the testing process took approximately 10 months beginning in March 2005 and concluding in December 2005.

The dairy owner also reported a number of delays in the construction phase. With respect to construction permitting delays, the independent plan check engineer did not understand the electrical components of the generator building, causing an approximate two month delay in the permitting process (it took about three months to get the permit). This delay resulted in the loss of the original concrete contractor, leading to construction delays and some increased costs. Overall vendor supply issues led to marginal delays in the project as the dairy owner waited to receive necessary materials to move forward.

Another obstacle facing this project was the cumbersome and time consuming process of getting net metering legislation passed in to allow net electricity generated by a utility customer to be credited against electricity consumed. Although advantageous, this legislation, AB 2228 (Negrete McLeod), was not passed until 2003. After the law's passage, issues with the utility's interpretation of tariffs had to be worked out with the California Public Utilities Commission. It should be noted that AB 2228 sunsets on January 1, 2006; however, new legislation, AB 728 (Negrete McLeod), was recently signed by the Governor. This new bill extends and expands the biogas net metering program through December 2009.

VI. Animal Distribution

At the time of application submittal, the dairy owner planned an expansion to approximately 1,200 cows (including milking and dry). For the 90-day study period, January through March 2006, there were an average of 1,400 cows on the dairy, of which 800 were lactating cows, 150 dry cows, and 450 heifers and calves. An additional 280 calves and heifers are housed off-site.

The lactating cows are housed primarily in freestall barns approximately 22 hours each day, where they have access to attached dry lots approximately 8 hours each day in dry months. They spend the other two hours in the milking parlor. The dry cows and heifers spend approximately 16 hours in drylots and 8 hours in feed aprons. The calves are housed separately.

Separate from the digester project, the dairy owner converted one of the large loafing barns into an additional free stall barn with attached dry lots. This conversion allowed for an additional two tanker loads per day of manure to be collected for the digester.

VII. Manure Collection and Processing

A vacuum scrape collection system collects manure from the feed sprons and freestall alleys. The areas are scraped 6-7 times daily, and manure is collected with one trailer-mounted Loewen 2,500 gallon capacity vacuum unit. It is estimated that approximately 75-80% of the available manure is collected in these areas. The remainder, dry lot manure, is not collected for the digester. An estimated 15,000 gallons of manure per day is transferred to the digester.

Trailer-mounted Loewen vacuum unit

To maintain optimum solids content, water from the parlor, wash area, and holding yard is plumbed to bypass the digester system and is deposited directly into a storage pond. When needed, the manure can be diluted with this water to achieve the targeted 12%-13% solids entering the digester.

The undiluted manure is deposited directly into an influent collection tank at the input end of the digester and is gravity fed by displacement over a weir into the digester vessel.

VIII. Biogas Utilization System

The concrete mesophilic (35°C or 95°F) plug flow digester has a hydraulic retention time of about 20 days. The digester is rectangular and measures 30' wide x 150' long. The depth at the center of the digester is 14 feet. The digester is covered with a flexible, impervious top. Approximately 15,000 gallons of manure slurry are fed to the digester per day. To enhance decomposition of the manure, waste heat from the engine is used to heat the digester to approximately 100°F. A heat exchanger located on the generator produces hot water which is circulated through heat exchange lines in the digester. This raises the digester temperature to allow greater gas production. The generator is run continuously, unless shutdowns are necessary for maintenance, to maintain the digester temperature.

At the time of the grant application, it was estimated that the system would produce approximately 62,105 cubic feet per day of biogas. The produced biogas, with an estimated 70% methane, is currently used to power the 180-kW capacity IC Caterpillar 3406 engine. During the 90-day study period the system produced far more biogas and electricity than could be used for dairy operations connected to the engine. The dairy owner reports having no incentive to generate surplus electricity for which he would have received little to no compensation. Therefore, excess gas not used by the engine was flared during this period. The dairy owner is considering the possibility of setting up his system so that maximum dairy load is connected to the generator to further reduce utility charges. This is discussed further below.

Plug flow digester

As the digester is fed, effluent is hydraulically displaced. Digested manure flows out of the digester into a concrete effluent storage tank from which it is pumped to a screw press separator to

separate fibers from liquids. The effluent tank is protected by emergency overflow pipe that flows by gravity to the storage lagoon. The separated solids are composted and used as bedding for the cows in the freestall barns. The liquid effluent gravity flows to a storage pond where it is then applied as irrigation to surrounding cropland at agronomic rates.

Solid liquid separator

IX. Biogas and Energy Production

In the initial design specifications, it was estimated that the digester would produce 62,105 cubic feet of biogas per day from manure from 1,200 cows. An estimated electricity production of 5,300 kWh/day from a total available capacity of 180 kW was expected. Given an estimated average of 3,574 kWh/day, it was assumed that the engine would operate at about 83% capacity. It was expected that the engine would operate at an average of 165 kW when the farm animal population reached 1,200 cows of mixed breeds.

Biogas collected from the digester is piped underground to the engine room that is part of a 30' x 50' combined engine room and shop building. The biogas is used to fuel the 180 kW capacity genset. A wall separates the generation equipment from the shop area. Wiring connects the generator output to the electrical service. Appropriate safety relays are part of the system and meet requirements of the utility.

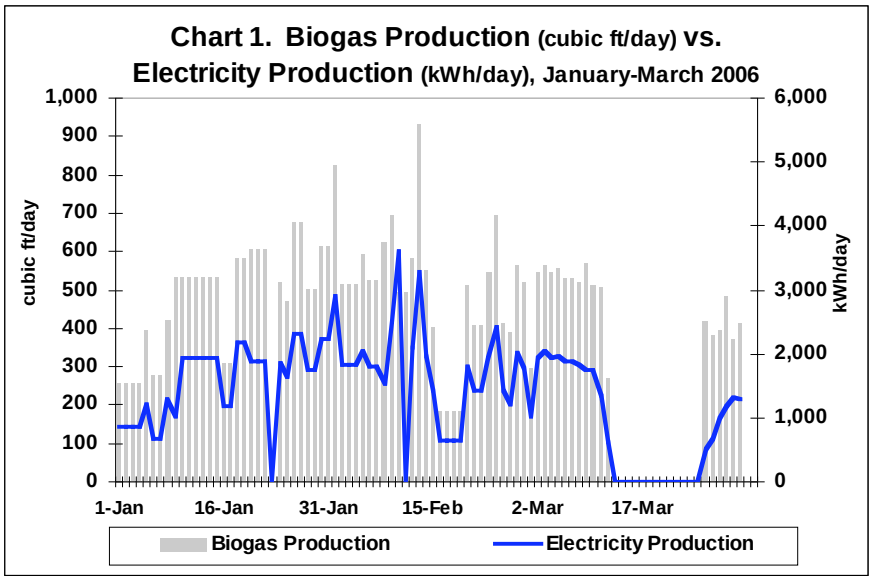
Biogas equipment and hot water controls manage the biogas and hot water flow to and from the engine room. As mentioned above, hot water generated in the engine cooling system is used to heat the digester. Excess hot water can be recovered in the future for farm use.

Engine generator room

Although biogas was produced as early as spring 2005, the system began operating on January 1, 2006, and has been producing electricity from biogas continuously since that date. Some generator downtime was reported during the 90-day study period.

Issues with the biogas production meters should be noted before further discussion. The biogas meter is located inside the generator building and measures only the biogas used by the generator. The excess biogas that is flared is not represented in the figures reported below.

Chart 1 compares biogas usage to electricity production for the 90-day startup period. Reported biogas usage declined from an average of about 55,149 cubic feet/day in January to about 41,161 cubic feet/day in February. Biogas usage declined again in March, with reported biogas usage reaching an average of 31,910 cubic feet/day. However, downtime increased each month with 56 hours in January, 162 hours in February, and 267 hours in March. Again, the biogas measured is gas that went into the engine and does not include gas that was flared when the engine was either off or being run in limited output mode during startup and benchmarking.



As mentioned above, the system produced far more biogas and electricity than needed for the dairy operations connected to the generator. The excess biogas was flared. The dairy owner is considering the possibility of setting up his system so that maximum dairy load is connected to the generator to further reduce utility charges. This is discussed further below.

Engine generator

Electricity production reached an average of 1,916 kWh/day in January but fell to 1,409 kWh/day in February. Electricity production declined again to an average of 851 kWh/day in March. The system operated at an average of 22.2 hours/day in January, 18.2 hours/day in February and 15.4 hours/day in March. Again, not all available biogas was used to produce electricity due to the lack of compensation for excess power sent to the utility.

Beginning in January 2006, the dairy owner was set up to take advantage of the net metering law, AB 728 (Negrete McLeod), which allows electricity generated by a customer to be credited against electricity consumed. The local utility PG&E offers the Net Energy Metering Service for Biogas Customer-Generators (NEMBIO) rate schedule as an option for customers with an eligible biogas digester operating in parallel with PG&E.

NEMBIO works with a second, time-of-use rate (TOU) schedule, referred to as the otherwise applicable rate schedule (OAS). The OAS is the basis for not only the charges, but also the generation credits for any electricity exported to the grid. The credits for export are based only on the Generation rate component of the rate schedule. All other charges, including but not limited to transmission charges, distribution charges, monthly customer charges, minimum

charges, demand charges, and non-energy related charges are not included when calculating the generation credit for exported electricity.

PG&E aggregates the load (usage) of all eligible metered time-of-use (TOU) accounts associated with the dairy operations designated on the interconnection agreement to determine NEMBIO credits and/or charges annually. All of the aggregated account serving the dairy operation must be located on property next to the dairy.

The dairy owner will be billed monthly for all charges other than the Generation Rate Component charges on all eligible accounts on the dairy. Then, at the end of each relevant period (12 monthly billing cycles commencing on the anniversary date of final interconnection), PG&E will complete an annual reconciliation of generation credits and unbilled generation rate components. At the end of the 12-month period January-December 2006, these credits and charges will be zeroed out. The utility is not required to pay for the unused portion of the generation credit.

There are 11 electricity meters on the farm. Of the 11 meters, one meter in the generator building is pre-grid (or the load is connected to the generator), and this serves the manure separator, one deep well, freestall lights, a manure pump, and the generator load (the gas blower, water pump, radiator motor, engine water pump, building exhaust fan, battery chargers, and so forth). All of these items are powered using on-farm electricity. Of the remaining meters, eight meters serve general farming and dairy operations and are net metered according to the NEMBIO schedule explained above (four run irrigation pumps, and the other four are for the milk barn, deep well, support building, calving shed and office). The remaining two meters are for housing and are not currently net metered. The dairy owner plans to run wires to the milk barn to connect its load to the generator. The project is expected to be completed by fall 2006.

It is advantageous to interconnect the biogas digester generating facility to the dairy accounts with the greatest load. The largest savings from generation of power are in the offset of the dairy's energy needs (or purchases from the utility company). Unfortunately, the dairy owner is not reaping the full possible financial benefits of generating electricity. Full benefit would be realized if the generator were connected to the main load at the dairy, primarily the milking parlor and other meters mentioned above. If that were the case, as electricity was produced, the electricity usage for the dairy would be offset (the amount of electricity imported from the grid would be greatly reduced). This would reduce the total power purchased from the utility and would be valued at the full energy rate as specified in their applicable rate schedule. As mentioned above, the dairy owner is considering possibly setting up his system so that maximum dairy load is connected to the generator to reap these benefits.

Other savings associated with power production would come from any accrued net generation credits that could be used against unbilled generation charges on the other dairy accounts during the 12 month relevant period (as explained above). For any time-of-use in which the electrical production exceeds the usage, a generation credit would be accrued, valued at the applicable generation rate component.

There are additional concerns worth noting when discussing utility issues. One particular issue centers on demand charges. The dairy is on the TOU-PA-5 rate schedule, which specifies that maximum demand is established by the measured maximum kilowatt input recorded during any 15-minute metered interval. So, at any point when the digester system is down (for example, due to maintenance), that period of highest recorded demand will be used to establish the demand charges for the month. Given this, it is likely that the dairy owner will not be successful

in reducing demand charges each month as the system will require some down time. The dairy owner has explored purchasing a backup diesel generator to which some dairy load could be connected and removed entirely from the utility altogether with the goal of reducing demand charges.

Another option to reduce demand charges would be using of a backup generator during times when the digester system is down for maintenance or repair. However, it would require much effort by the dairy owner to ensure optimal performance and the operational timing of each generator. Additionally, the dairy owner will need to compare the potential cost savings to the additional cost and time associated with running the backup generator. To date, due to little to no reimbursement for excess generated power, the dairy owner has found no reason to take on the added burden.

The dairy owner is hopeful that someday the utility will purchase the excess energy produced on the dairy. However, there are currently no power purchase agreements available to biogas customer generators and no requirement for the utility to pay the full retail rate for this energy. Net metering is the only benefit available to the dairy owner.

Unfortunately, monthly utility bills and NEIMBO billing are not available for review and subsequent discussion in this report. PG&E is currently working on issuing utility bills for the period beginning January 2006 to current. An issue with one of the utility meters required that all the utility and NEMBIO billings be recalculated. The issue has been resolved, and PG&E expects to issue a new set of bills within several weeks. Therefore, revenues from the generation of power can not be assessed at this time. It is hopeful that a full discussion will be included in the final report to be submitted to the California Energy Commission (Energy Commission) by August 31, 2006.

X. Energy Usage

Utility bills for the 90-day period were not available for review. As mentioned above, PG&E is working on issuing utility bills for the period beginning January 2006 to current and is expected to release them soon. More detailed analysis will be provided in the final report submitted to the Energy Commission.

XI. System Performance

The performance of the system thus far has been below original expectations. Table 1 compares the system design performance calculations with the actual performance for the 90-day period January-March 2006. Since these are considered startup months and the data covers a very short period of time, these should be considered preliminary results. Also, a great deal of the available biogas was flared during the period, thereby lowering the performance figures. The flared biogas is not metered, so the amount of gas being flared cannot be estimated.

In the grant application, biogas production was expected to reach 62,105 cubic feet/day from the manure from 1,200 cows, or 52 cubic feet/day of biogas per cow. The daily biogas production was estimated to result in electricity generation of 2.98 kWh per cow per day. For the 90-day period studied, the design calculations for biogas were not matched. There are several reasons the digester did not perform at original expectations. First, as previously

mentioned, the biogas production figures during the study period represent only the biogas that was utilized by the digester. Flared biogas was not measured.

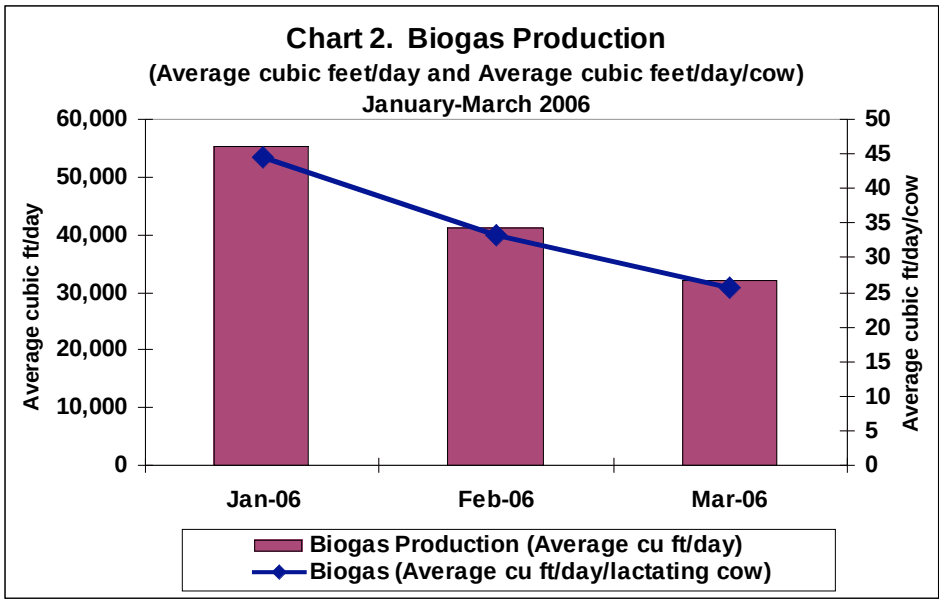
Table 1: Digester Design and Actual Performance

	Design	Actual January-March 2006 Average
Cows	1,200	1,400
Manure Slurry	Vacuum scraping	Vacuum scraping
Total gallons per day	19,289	15,000
Digester Specifications		
Type	Plug flow	Plug flow
Digester Feeding Mode	Intermittent (1X day)	Intermittent (2X day)
Retention Time (days)	22	22
Gas Production*		
Total (cubic feet per day)	62,105	42,740
Per Cow (per day)	52	30.53
Electrical Output		
Generator Capacity (kW)	180 kW capacity 165 kW estimated average electrical output	165 kW
Generator Availability (operational hours/day)	20	19
Total (kWh/year)	1,304,551 given 180kW at 83% capacity	500,991 or 32% capacity
Total per day (kWh)	3,574	1,373
Total per cow (kWh/day)	2.98	0.98

* Measured biogas production is only that biogas utilized by the generator. Flared biogas is not metered at this time.

For the 90-day period, an average of 42,740 cubic feet of biogas per day was metered. This resulted in an average metered biogas production of 30.53 cubic feet/day per cow for an average of 1,400 cows. This resulted in an average electricity generation of 0.98 kWh per cow per day. Chart 2 compares the average cubic feet of biogas production per day and per cow for January, February, and March 2006. Again, not all manure reached the digester, and not all the gas reached the engine. A portion of the gas is flared since any electricity produced in excess of the site load is not purchased by the utility.

As noted above, the average electricity generation was 1,373 kWh per day compared to an originally estimated 3,574 kWh per day. It should be mentioned that the dairy owner is purposefully not running the system as much as he could. In fact, the dairy owner reports running the system less than 25% of the time. Unfortunately, the costs of running the system outweigh the benefits because he is not compensated for surplus energy.



Though he will be able to better assess the situation once his utility bills and NEMBIO summary are available, he estimates that he has accrued more net generation credits than he can use toward the generation charges on his other accounts. The dairy owner reports that it is actually more economically advantageous not to run the generator than to run it due to the costs of keeping the system running. Once additional load is connected, this situation may change. However, until the utility bills are available, a full analysis can not be completed.

The dairy owner has reported that there have only been minor problems with system operation thus far. In March 2006, the digester overheated, killing the bacteria necessary for generating biogas and necessitating a shutdown for about a week and a half. The dairy owner is still working to find the best way to maintain optimum temperature of the digester. Overall, most system shutdowns have either been due to minor mechanical maintenance issues, such as oil changes or valve repairs, or the system has been turned off by the dairy owner due to the financial disincentive mentioned above.

The dairy owner reports that the system is fairly easy to run, but he feels that his staff needs some additional training on the machinery. Additional training will allow staff to handle any mechanical issues that may arise in the dairy owner's absence.

Because the project is still in the startup phase, some system adjustments and improvements have been required. The dairy owner continues to monitor system performance and to make modifications as necessary.

XII. Heat Utilization

Recovered heat is used to heat the digester in order to maintain a temperature of approximately 100°F. This has been helpful in enhancing the decomposition of manure.

The dairy facility uses propane for heating. At this time, there are no cost savings associated with the use of recovered heat. The dairy owner plans to run water lines to the milk barn to recirculate hot water from the generator to heat parlor water for barn cleanup. The dairy owner plans to do this when electrical lines are pulled to the milk barn by fall 2006. If this plan is implemented, additional cost savings could occur.

XIII. Dairy Owner Qualitative Feedback

On a scale from one to four, the dairy owner was asked to rate his experience in a number of areas concerning the digester project. The specific questions, along with their monthly and average rankings, are included in Table 2.

Table 2: Qualitative Questions

Questions Ranked 1-4, with 1=poor and 4=excellent	**January 2006**	**February 2006**	**March 2006**	**Average**
1. **Ease in operating the biogas production and biogas to electricity systems**	3	2	3	2.67
2. **Extent to which system gives advantage to your dairy manure management**	3	3	3	3
3. **Extent to which the system helps with odor control**	3	3	3	3
4. **Extent to which the system helps with reducing water use for manure management**	2	2	2	2
5. **Extent to which system helps address electricity issues important to your dairy operation**	1	1	1	1
6. **Overall satisfaction with the system so far**	2	2	2	2
7. **Any other comments or recommendations?** My overall satisfaction with the system would increase if I were fairly compensated for the excess energy I produce.				